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ORIGINAL ARTICLE

# Electrocardiography as a predictor of left main or three-vessel disease in patients with non-ST segment elevation acute coronary syndrome

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**Abstract** *Introduction:* Acute coronary syndrome remains the leading cause of morbidity and mortality worldwide. It will continue to rise as the prevalence of patients with obesity and diabetes increases. Patients with non-ST segment elevation acute coronary syndrome had a bad prognosis in patients with left main ± three vessel diseases, so early identification of these patients by electrocardiography if ST segment elevation in lead aVR ⩾0.5 m and maximal QRS duration of ⩾90 ms is important for the selection of optimal treatment.

*Materials and methods:* The study was designed as a multicenter cross-sectional study that was conducted on 150 patients presenting with non-ST segment elevation acute coronary syndromes, 80 patients had non-ST segment elevation myocardial infarction and 70 patients had unstable angina in the period between January 2009 till January 2010. All patients had full history, clinical examination, laboratory investigations including lipid profile, blood glucose, cardiac Troponin T and renal function, also electrocardiography and coronary angiography was done to prove the diagnosis. ECG was analyzed to assess the degree of ST segment elevation in aVR, ST segment depression in other leads and the maximal QRS was analyzed. Coronary angiography was done to all patients with detection of the presence of left main 50% stenosis at least with or without other three significant coronary vessels showing 70% stenosis or more to be included in 67 patients in group I. Group II include 83 patients with normal coronaries or significant stenosis in one or two vessels.

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*Results:* Left main coronary stenosis with or without three significant coronary vessel stenosis occurs in 67 patients (44.7%) in group I vs. 83 patients (55.3%) in group II (i.e. without left main disease or three vessel disease). The mean age of the patients 59 $\pm$ 9 years which was not significant in both the groups ($P > 0.05$). The following also were not significant gender, smoking, dyslipidemia, renal impairment, hypertension and positive family history. Diabetes was considered significant in 44 patients (65.7%) in group I in comparison to 34 patients (41%) in group II ($P < 0.003$). Positive Troponin T was also significant in group I in 47 patients (70.1%) vs. 33 patients (39.8%) in group II. ST segment elevation $\geqslant$0.5 mm in lead AVR is significant in group I in 52 patients (77.6%) vs. 29 patients (34.9%) in group II ($P < 0.001$). ST segment depression $\geqslant$0.5 mm in leads other than aVR is significant in group I in 56 patients (83.6%) vs. 41 patients (49.4%) in group II ($P < 0.001$). The presence of QRS duration > 90 ms in the admission ECG was significant in group I in 45 patients (67.2%) vs. 16 patients (19.3%) in group II ($P < 0.001$).
*Conclusion:* ST-segment elevation in lead aVR $\geqslant$0.5 mm and QRS duration $\geqslant$90 ms are good electrocardiographic predictors of left main or three vessel disease in patients with non-ST segment elevation acute coronary syndrome.



## 1. Introduction

Acute coronary syndrome remains the leading cause of morbidity and mortality worldwide will continue to rise as the prevalence of patients with obesity and diabetes increases.[1]

Patients with NSTE-ACS had a worst prognosis in patients with LM/3VD disease, so an early identification of patients with LM/3VD disease is an important factor in the prognosis and selection of the optimal treatment strategy in patients with NSTE-ACS.

## 2. Aim of the work

To demonstrate if ST-segment elevation in lead aVR of $\geqslant$0.5 mm and maximal QRS duration of $\geqslant$90 ms, are useful predictors of left main and/or three vessel disease (LM/3VD) in patients presenting with non-ST elevation acute coronary syndrome.

## 3. Patients and methods

The study was designed as a multicenter cross-sectional study that was conducted on 150 patients presenting with non-ST segment elevation acute coronary syndromes, 80 patients had non-ST segment elevation myocardial infarction and 70 patients had unstable angina in the period between January 2009 till January 2010.

### 3.1. Inclusion criteria

1. Patients with typical chest pain attributed to cardiac ischemia lasting at least 20 min and involving an unstable pattern of pain, including rest pain, new onset, severe or frequent angina (accelerating angina).
2. Fully assessable ECG on admission.
3. Fully assessable angiographic data during hospitalization.

### 3.2. Exclusion criteria

1. Conditions precluding the evaluation of QRS duration or ST segment on the ECG [LBBB, RBBB, left ventricular hypertrophy, ventricular pacing, ventricular pre-excitation, non-ischemic cardiomyopathy, or antiarrhythmic drugs].
2. Transient or persistent ST segment elevation in leads other than AVR.
3. Q-wave acute MI on presentation.
4. Recent [< 6 months] PCI, or previous CABG.

All patients had full history clinical examination, laboratory investigations including lipid profile, blood glucose, cardiac Troponin T and renal function, also electrocardiography and coronary angiography was done to prove the diagnosis. ECG was analyzed to assess the degree of ST segment elevation in aVR, ST segment depression in other leads and the maximal QRS duration was analyzed. Coronary angiography was done to all patients with detection of the presence of left main 50% stenosis at least with or without other significant coronary vessels showing 70% stenosis or more to be included in 67 patients in group I. Group II include 83 patients with normal coronaries or significant stenosis in one or two vessels.

## 4. Results

### 4.1. Demographic data

1. Age: It ranged from 29 to 81 years with a mean of 59 $\pm$ 9 years.
2. Sex: It includes 115 males (77%) and 35 females (23%).

**Table 1** Incidence of risk factors in the study.

| Risk factors | No. | % |
|---|---|---|
| Hypertension | 99 | 66 |
| Dyslipidemia | 71 | 47 |
| Diabetes mellitus | 78 | 52 |
| Smoking | 95 | 63 |
| Positive family history | 26 | 17.3 |
| Renal impairment | 25 | 16.7 |

*4.1.1. Risk factors*

It includes hypertension (66%), dyslipidemia (47%), diabetes mellitus (52%), smoking (63%), family history (17.3%) and renal impairment (cr > 1.5) (16.7%) (Table 1).

*4.2. Univariate analysis to detect the relationship between individual predictors and incidence of LM/3VD*

There were two groups; group I were patients with left main coronary stenosis of ⩾50% with or without three significant coronary artery stenosis occurred in 67 patients (44.7%) and group II were patients with normal, one vessel and two vessel coronary artery disease included in 83 patients (55.3%).

*4.2.1. Relationship between risk factors and group I and II*

Age (61 ± 9.6 years) in group I vs. (57 ± 9.5 years) in group II ($P > 0.05$), gender include 52 males (77.6%) and 15 females (22.4%) in group I vs. 63 males (75.9%) and 20 females (24.1%) in group II ($P > 0.05$), smoking include 45 patients (67.2%) in group I vs. 54 patients (65.1%) in group II ($P > 0.05$), dyslipidemia in 35 patients (52.2%) in group I vs. 43 patients (51.8%) in group II ($P > 0.05$), renal impairment in 11 patients (16.4%) in group I vs. 14 patients in group II ($P > 0.05$), hypertension in 49 patients (73.1%) in group I vs. 50 patients (60.2%) in group II ($P > 0.05$), positive family history occurred in 12 patients (17.9%) in group I vs. 14 patients (16.9%) in group II ($P > 0.05$). All of the previous risk factors showed no significant relationship between each item and group I and II, however diabetic patients 44 patients (65.7%) were significant in group I vs. 34 patients (41%) in group II ($P < 0.003$) (Table 2).

*4.2.2. Relationship between positive troponin T and group I and II*

In group I 47 patients (70.1%) had positive Troponin T vs. 33 patients (39.8%) in group II with a high significant value ($P < 0.001$) (Table 3).

**Table 2** Risk factors in group I and II.

| | Group I | Group II | *P* Value |
|---|---|---|---|
| Mean age in years | 61 ± 9.6 | 57 ± 9.5 | >0.05 |
| Gender | | | |
| Males | 52 (77.6%) | 63 (75.9%) | >0.05 |
| Females | 15 (22.4%) | 20 (24.1%) | |
| Smoking | 45 (67.2%) | 54 (65.1%) | >0.05 |
| Dyslipidemia | 34 (52.2%) | 43 (51.8%) | >0.05 |
| Renal impairment (cr > 1.5) | 11 (16.4%) | 14 (16.9%) | >0.05 |
| Hypertension | 49 (73.1%) | 50 (60.2%) | >0.05 |
| Positive family history | 12 (17.9%) | 14 (16.9%) | >0.05 |
| DM | 44 (65.7%) | 34 (41%) | <0.003 |

**Table 3** Showing correlation between positive troponin T and group I and II.

| | Group I | Group II | *P* Value |
|---|---|---|---|
| Troponin T (>0.1 mg/ml) | 47 (70.1%) | 33 (39.8%) | <0.001 |

*4.2.3. Relationship between ECG and group I and II*

*4.2.3.1. ST segment elevation > 0.5 mm in AVR lead.* In group I there were 52 patient (77.6%) who had ST-segment elevation in AVR lead ⩾0.5 mm in the admission ECG while in group II there were 29 patients (34.9%) who had ST-segment elevation ⩾0.5 m in AVR in the admission ECG with a high significant value ($P < 0.001$) i.e. ST segment elevation ⩾0.5 m in AVR lead is a good predictor of left main or three vessel disease (Table 4).

*4.2.3.2. ST segment depression ⩾0.5 mm in leads other than aVR.* It occurred in 56 patients (83.6%) in group I vs. 41 patients (49.4%) in group II which shows a high significant value (Table 5).

*4.2.3.3. Relationship between QRS duration ⩾90 ms in all leads.* The presence of QRS duration of ⩾90 ms in the admission ECG was significantly more prevalent in group I. In this group 45 patients (67.2%) had this finding vs. 16 patients (19.3%) in group II (Table 6).

*4.3. Multivariate analysis to detect the actual significance of each individual predictor in the presence of other significant variables*

A multivariate logistic regression analysis was used to identify clinical predictors of LM/3VD among the variables associated ($P < 0.05$) with this diagnosis on univariate analysis (Table 7).

**Table 4** Showing correlation between ST segment elevation in AVR lead in group I and group II.

| | Group I | Group II | *P* Value |
|---|---|---|---|
| ST-segment elevation ⩾ 0.5 mm in AVR lead | 52 (77.6%) | 29 (34.9%) | <0.001 |

**Table 5** Showing correlation between ST segment depression in leads other than in AVR in group I and group II

| | Group I | Group II | *P* Value |
|---|---|---|---|
| ST-segment depression ⩾ 0.5 mm in leads other than aVR | 56 (83.6%) | 41 (49.4%) | <0.001 |

**Table 6** Showing correlation between QRS duration in group I and group II

| | Group I | Group II | *P* Value |
|---|---|---|---|
| QRS duration of ⩾90 ms | 45 (67.2%) | 16 (19.3%) | <0.001 |

**Table 7** Univariate and multivariate *P* value.

| Variable | Univariate *P* value | Multivariate *P* value |
|---|---|---|
| Diabetes | <0.05 | >0.05 |
| Positive Troponin T | <0.05 | >0.05 |
| ST-segment elevation ⩾ 0.5 mm in lead aVR | <0.001 | <0.001 |
| ST-segment depression > 0.5 mm | <0.05 | >0.05 |
| QRS duration ⩾ 90 ms | <0.001 | <0.001 |

**Table 8** Sensitivity, specificity, positive predictive value, and negative predictive value of electrocardiographic predictors.

| Predictor | Sensitivity (%) | Specificity (%) | Positive predictive value (%) | Negative predictive value (%) |
|---|---|---|---|---|
| ST-segment elevation ⩾ 0.5 mm in lead aVR | 77 | 65 | 64 | 78 |
| ST-segment elevation ⩾ 1 mm in lead aVR | 40 | 92 | 81 | 65 |
| ST-segment elevation ⩾ 1.5 mm in lead aVR | 14 | 98 | 91 | 59 |
| QRS duration ⩾ 90 ms | 67 | 57 | 73 | 75 |
| QRS duration ⩾ 100 ms | 35 | 99 | 96 | 65 |

Univariate analysis indicated that many factors were related to LM/3VD. In the multivariate model, ST-segment elevation in lead aVR ⩾0.5 mm and QRS duration ⩾90 ms were the strongest predictors of LM/3VD. The other variables that were associated with LM/3VD ($P < 0.05$) on univariate analysis were not significant predictors of LM/3VD.

The sensitivity and specificity of ST-segment elevation in lead aVR ⩾0.5 mm and QRS duration ⩾90 as predictors of left main and/or three vessel disease in patients with non-ST segment elevation acute coronary syndrome is shown in the following table.

From this table, we can conclude that:

- For each successive 0.5 mm increase in the definition of greater ST-segment elevation in lead aVR (from ⩾0.5 to ⩾1.5 mm), there was a stepwise increase in specificity from 65% to 98%, with a corresponding stepwise decrease in sensitivity from 77% to 14%.
- For each successive 10 ms increase in the definition of prolonged QRS duration (from >90 to >100 ms), there was a stepwise increase in specificity from 57% to 99%, with a corresponding stepwise decrease in sensitivity from 67% to 35% (Table 8).

## 5. Discussion

In our study, age was not a significant predictor of LV/3VD. This result is similar to that in the study of Gary et al., who conducted a study on 200 patients.[2] On the other hand Masami et al. observed that patients with LM/3VD were older.[3]

Gender did not play any significant role in the prediction of LM/3VD in our study. This is supported by Adamus et al., who examined 220 patients.[4]

Diabetes was found to be a significant predictor (on univariate analysis) for LM/3VD in our study, and this goes with the results of Masami et al. and the results of Claver et al., who examined 102 patients.[3]

Regarding hypertension, renal impairment and positive family history, in our study, there were no significant relationship between these variables and the incidence of LM/3VD, similar to that found by Masami et al. and Hubbard et al., who reported that there were no statistically significant differences in patients who had the previous risk factors and those who did not (66, 128).[3,5] However, Claver et al. found that renal impairment (cr ⩾ 1.5) was significantly associated with left main artery disease in univariate analysis.[6]

In our study, positive Troponin T was found to be significantly associated with (on univariate analysis) LV/3VD and this is supported by the results of the studies conducted by Masami et al. and Jurlander et al. (66, 130).[3,7] The later conducted a study on 117 patients.

However, positive Troponin T is not exclusively restricted to LM/3VD as it may occur with single or two critically diseased major epicardial coronary artery(s) (34).[8]

In the present study, QRS duration was shown to be highly significant factor in the prediction of LM/3VD. This is supported by the result of Jimenez-Candil et al., who examined the QRS duration of 502 patients (131).[9]

Studies conducted by Michaelides et al. have reported that exercise-induced QRS prolongation without bundle-branch block is directly related to the number of diseased vessels or segmental contraction abnormalities (135, 136).[10,11] Several studies have demonstrated that the specificity of QRS prolongation for the detection of myocardial ischemia is similar to that of ST-segment changes, whereas the sensitivity of the former is higher (137, 138).[12,13]

The study conducted by Murkofsky et al. reported that a QRS duration of >100 ms on a standard resting 12-lead ECG was a marker of decreased left ventricular function (139).[14] In the present study, a QRS duration of >100 ms was highly specific (99%), but insensitive (35%) for the prediction of LM/3VD.

In our study, involving 150 patients with NSTE-ACS, 44.7% presented with significant LM/3VD, a percentage higher than 31% is conducted by Masami et al. (66),[3] on 501 patients to evaluate the accuracy of non-invasive predictors of multi-vessels and/or left main disease in these patients, they found that many variables were associated with LM/3VD in univariate analysis, but in multivariate analysis only QRS duration ⩾90 ms, ST elevation in lead aVR ⩾0.5 mm, and positive Troponin T on admission were useful predictors of LM/3VD with the QRS duration ⩾90 ms holding the highest sensitivity (88%) while ST-elevation in aVR had the highest specificity (86%).

Also, this result is similar to another studies conducted by Rostoff et al., who studied 150 patients with ACS to asses the value of ST segment elevation in lead aVR and lead V1 for the detection of left main stenosis in these patients (140),[15] and Hengrussamee et al., who studied 26 patients with ACS (141).[16] Both studies concluded that in patients with acute coronary syndrome, lead aVR ST segment elevation is associated with the culprit left main coronary lesion.

In another study done by Masami et al., on 333 patients with NSTE-ACS, ST-segment elevation in lead aVR on admission was the strongest predictor of adverse outcomes at 90 days (142).[17] In contrast, neither ST-segment depression in other leads nor biochemical markers other than troponin T were found to carry independent prognostic information when entered into a multivariate analysis with ST-segment elevation in lead aVR.

Barrabes et al., studying 775 patients presenting with acute myocardial infarction without ST segment elevation in leads other than aVR and V1, reported that ST-segment elevation in lead aVR on admission was superior to ST-segment depression in other leads for predicting the risk of death in a first non-ST segment elevation acute myocardial infarction (143).[18] Their study found that ST-segment elevation in lead aVR was also related to the left main or three-vessel coronary disease.

Yamaji et al. found that ST-segment elevation in lead aVR, when combined with less ST elevation in lead V1, predicts significant left main disease. This electrocardiographic finding was associated with 50% mortality (144).[19]

Also, Gorgels et al. who studied 113 patients with ACS reported that ST-segment elevation in lead aVR accompanied by ST-segment depression in leads I, II and V4–V6 during episodes of angina is highly suggestive of LM/3VD in patients with rest angina (145).[20]

## 6. Conclusion

Based on the results of the current study we can conclude the following:

- ST-segment elevation in lead aVR of $\geqslant$0.5 mm and maximal QRS duration of $\geqslant$90 ms are useful predictors of Left Main and/or three-vessel disease in patients with non-ST-segment elevation acute coronary syndrome.
- ST-segment elevation in lead aVR came with a higher sensitivity (77%) and specificity (65%) when compared to the sensitivity and specificity of maximal QRS duration (67% and 57%, respectively).
- For each successive 0.5 mm increase in the definition of greater ST-segment elevation in lead aVR (from $\geqslant$0.5 to $\geqslant$1.5 mm), there was a stepwise increase in specificity from 65% to 98%, with a corresponding stepwise decrease in sensitivity from 77% to 14%.
- For each successive 10 ms increase in the definition of prolonged QRS duration (from $>$90 to $>$100 ms), there was a stepwise increase in specificity from 57% to 99%, with a corresponding stepwise decrease in sensitivity from 67% to 35%.

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